2010 Project to Build Combination Bevel Gear and Grist Mill gear Hand-cranked Model

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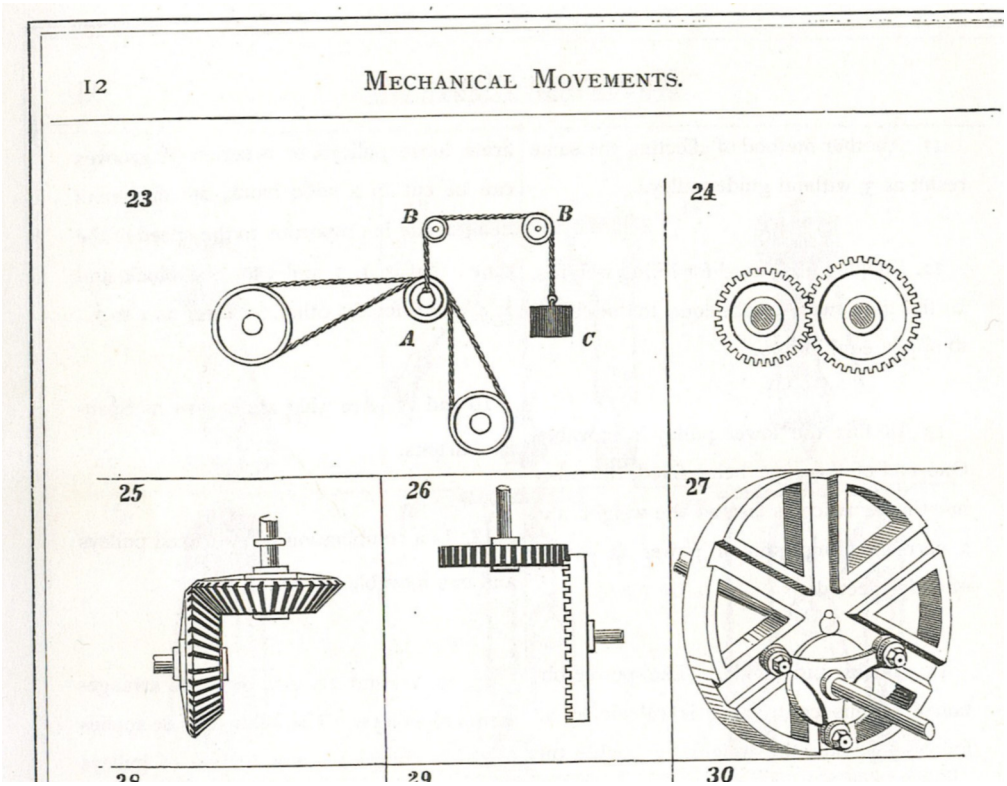
Model 25 Bevel Gear (January 2010)

I have been very pleased at how well my wood spur gears and rack & pinion gears have turned out on previous projects. I decided to stretch my horizons and see if I can make a wood bevel gear set.

In the 1800's, maybe earlier, grist mills needed to convert the horizontal power of water wheels into vertical power for the stone grist mill. They used the type of gear below with steel bands to keep the wood from pulling out from the stress.

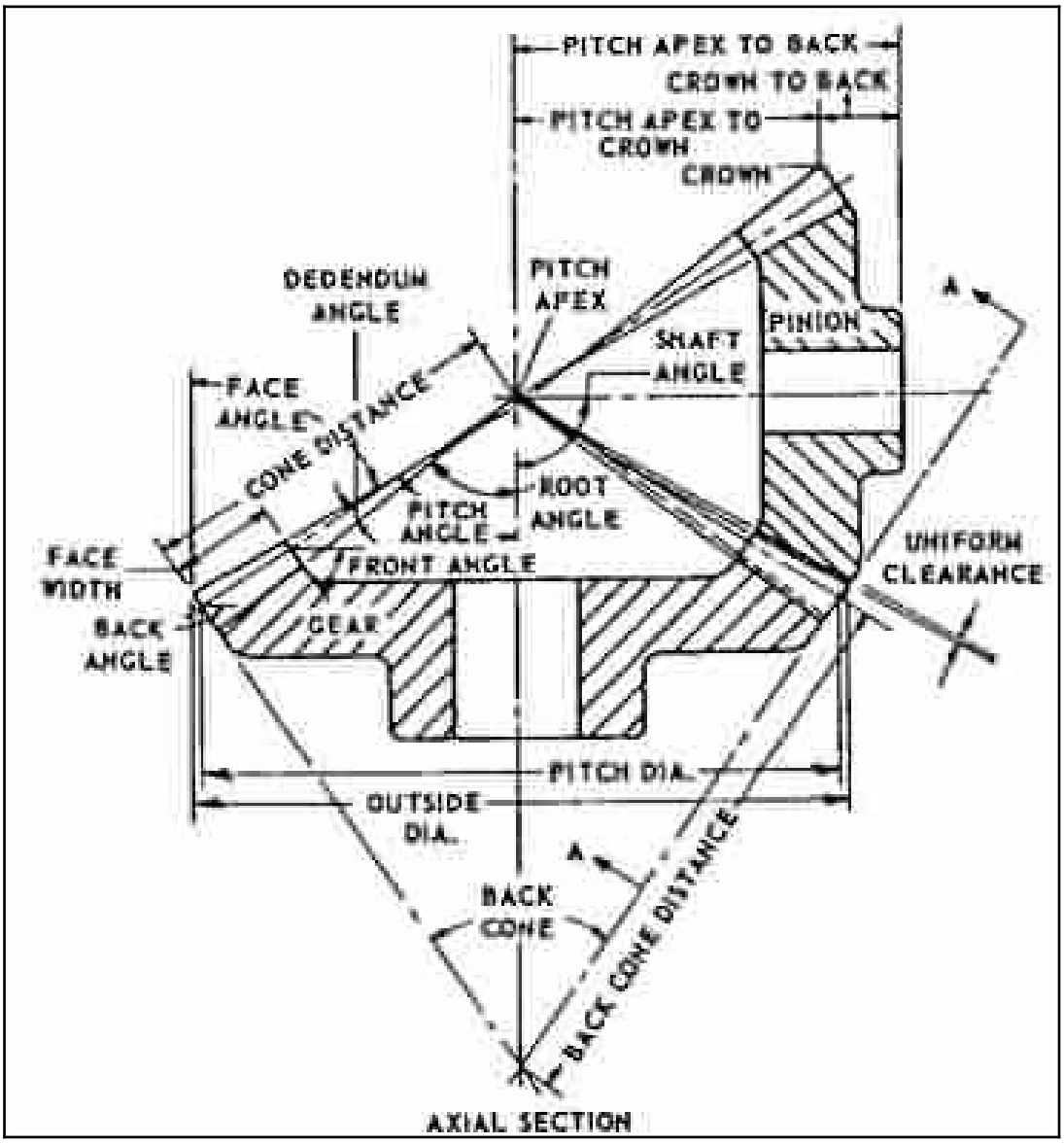
With the advent of the Industrial Revolution, machinery could make steel bevel gear sets as shown below:

Here is the concept drawing and of Model 25 bevel gear set from the 1868 book 507 Mechanical Movements:



I decided to make the bevel gear set first, then if I was successful, I would design the complete crank operated model.

I did a Google search and found this diagram which explains how bevel gear sets are designed:



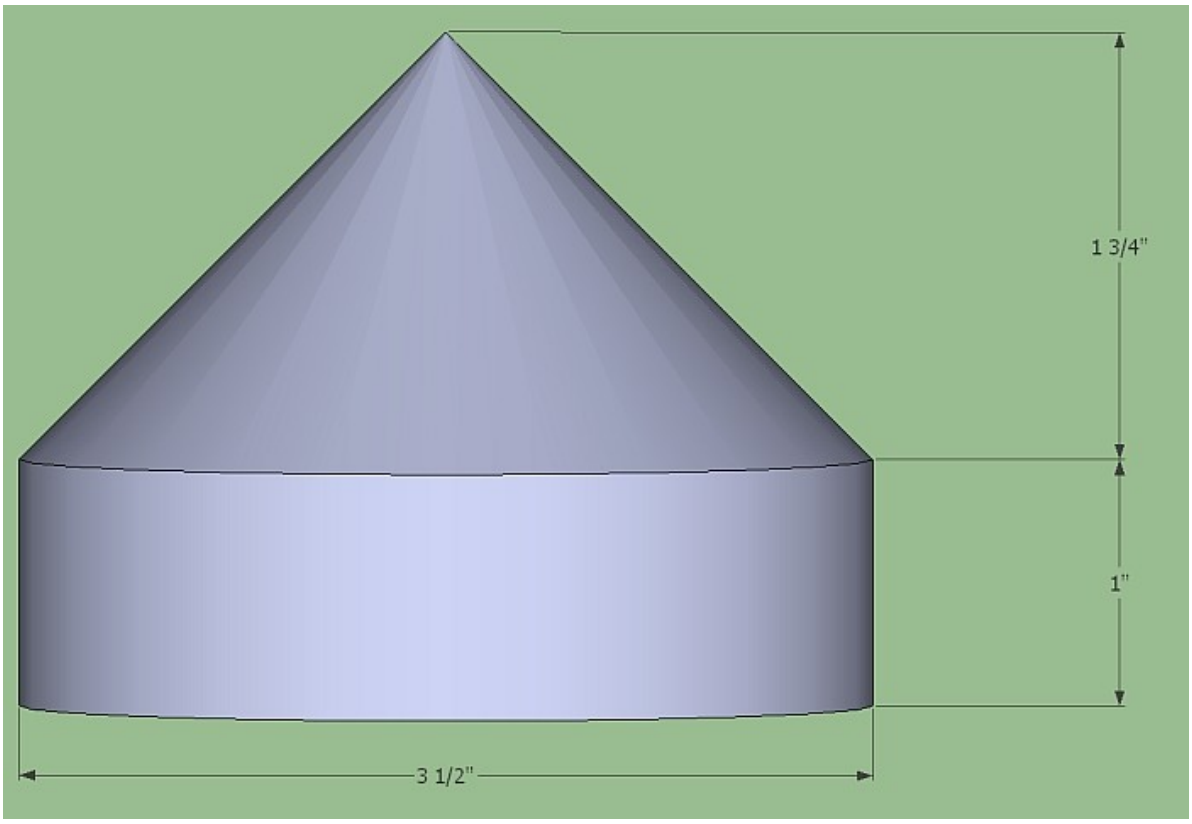
The key to designing a bevel gear is to understand that everything goes through an apex point as shown in the diagram.

The process I came up with for designing and making my bevel set was:

Use internet spur gear generator to generate the dimensions of the teeth on the OD of the gear. Measure these dimensions from the paper print-out. In Google sketchup, design the teeth pattern. Print the teeth pattern, then glue it onto the OD of the gear.

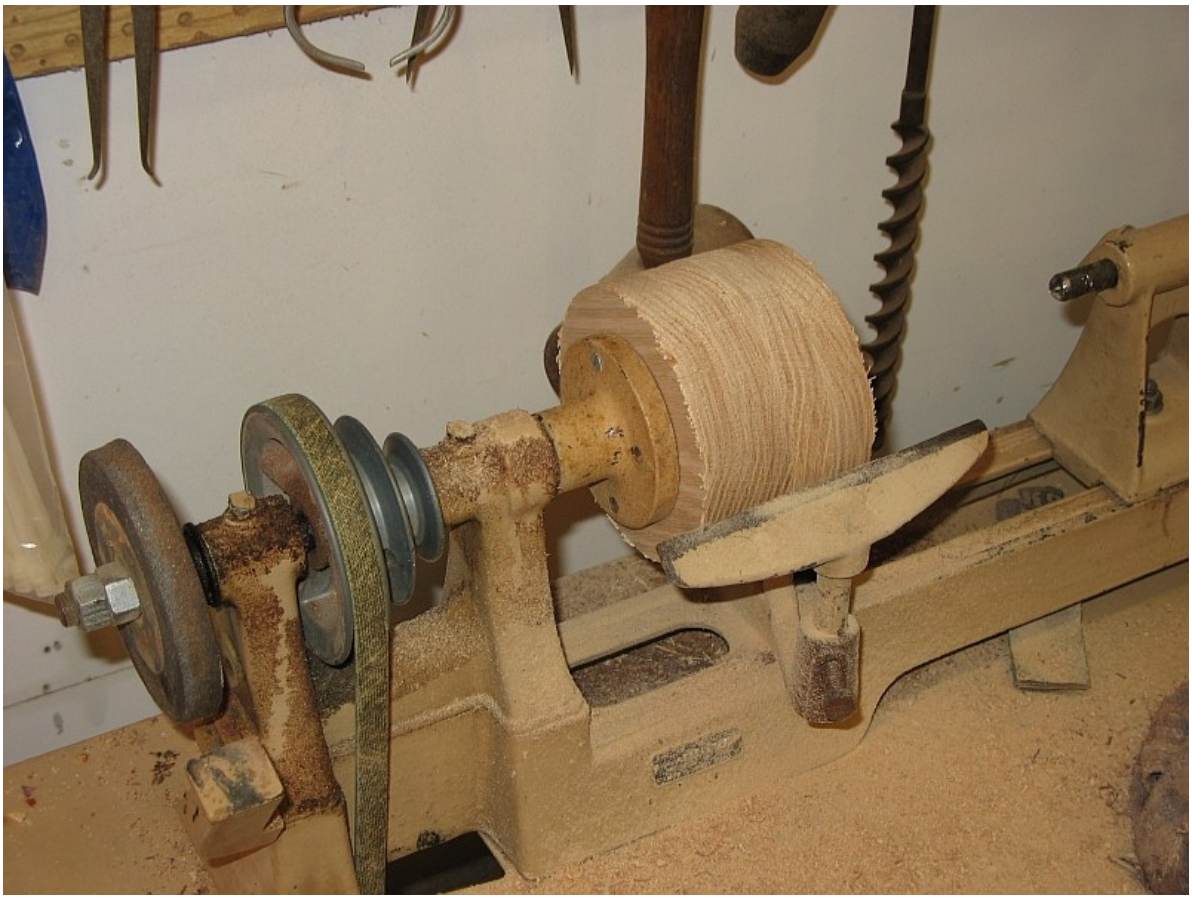
1. Make the gear blank conical coming to an apex like the diagram above.
2. Draw lines from the glued on OD gear teeth to the apex.
3. Make fixture and band saw teeth

Here is the google sketchup of the conical blank. I assumed a gear OD of 3" would be about right for my wood model.



I decide to turn the blank on my lathe using the faceplate. I could have turned between centers, but it takes less wood using the faceplate. I cut out (4) pieces of 3/4" thick oak 4.5" in diameter and glued them together.

Here is the blank turned to 3.5" OD on my lathe:



This was tought and sensitive turning since I was cutting end grain all the time. I kept my tools sharpened, but it was still tough turning.

I then turned 1 end to a cone:

I then glued the gear teeth pattern on the 3.5" OD of the gear. I also drew the lines from the glued on teeth to the apex of the cone:

The 1st time I glued on the paper gear teeth, I had a 1/4" gap between the place where the paper pattern should have over-lapped perfectly. Turned out my gear blank was slightly larger than 3.5". The circumference should be 2*Pi*r and this is 11" almost exactly. I cut a strip of notebook paper to check my OD size back on the lathe. I kissed the OD and used the 11" long piece of paper to get the OD just right. This is more precise than I usually do lathe work to !!

I bored a 3/4" shaft diameter in one end of the gear blank, so I could insert a 3/4" dowel to hold it in my band saw fixture:

I hold the OD of the gear with my hands to feed it into the band saw. When I got to this point, I realized the lines drawn from the glued on gear teeth to the apex were worthless..because I could not see them!! I just fed the fixture into the band saw until the blade hit full depth on the OD glued on gear teeth. On the next gear, I won't make an apex since it adds no value.

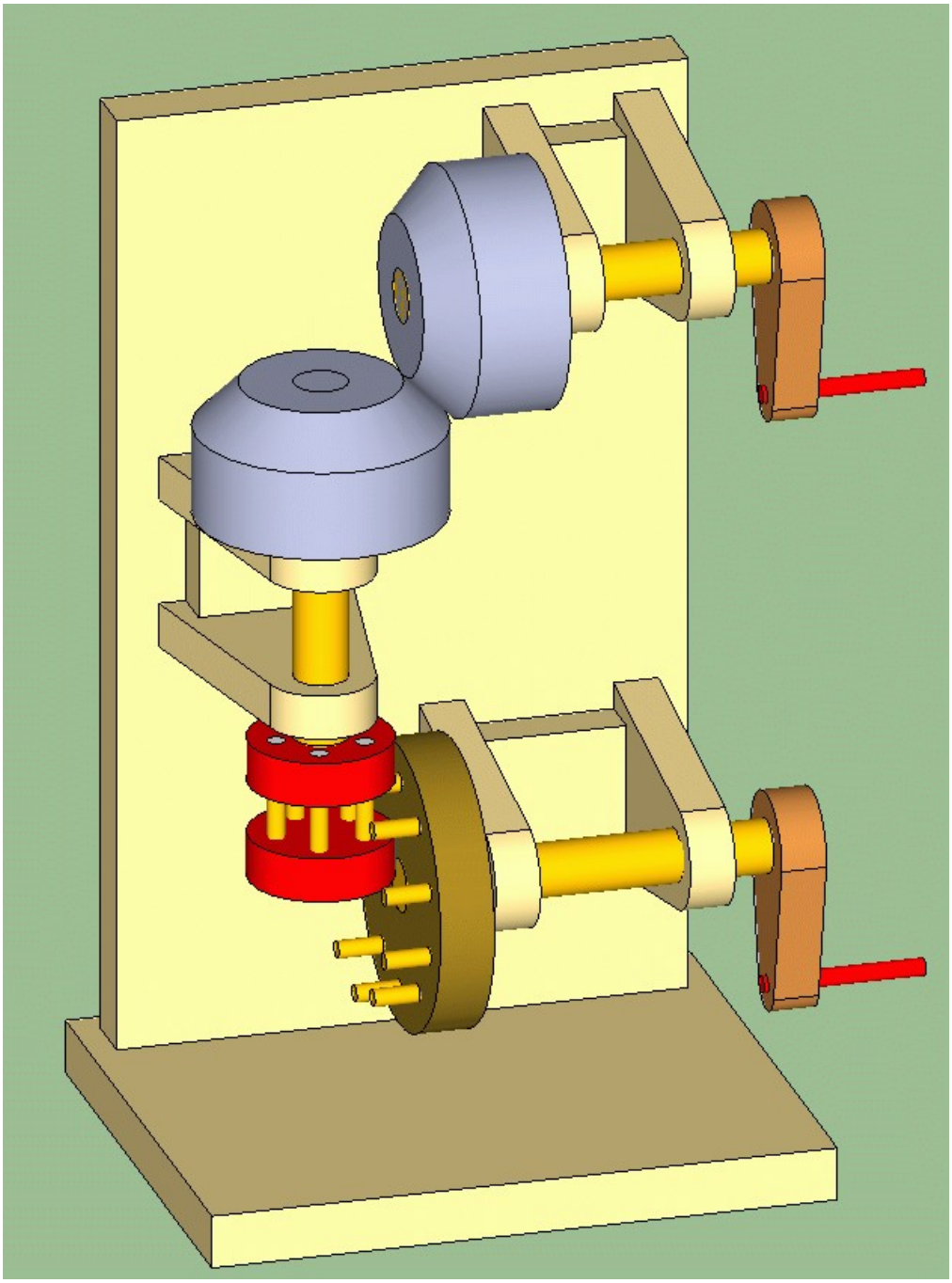
Another finding was that I could not clean out each tooth like I could on a 3/4" thick spur gear tooth. The blade is much longer (unsupported length) and wanders too much to clean out each tooth. The best I could do was make about 4 cuts in each tooth, leaving the thin slivers in the tooth.

I cleaned up each tooth using a chisel to break out the thin slivers, then the dremel with drum sander.....a round file and a flat mill file. These teeth are really fragile.

The bevel gear actually turned out pretty nice. Some teeth have little pieces chipped away, but nothing in life is perfect. I am now ready to make the mating gear, so I can see how well they run together !!

I left the cone point off the 2nd gear because it is not needed. Once the 2nd gear was completed, I tried out both gears in a temporary fixture:

The gears seem to work ok in the temporary set-up. Like the earlier wood spur gears I made, the spacing between gears is critical to how well they run together. Once I was sure I could make the spur gears, I designed the entire wood model in Sketchup:

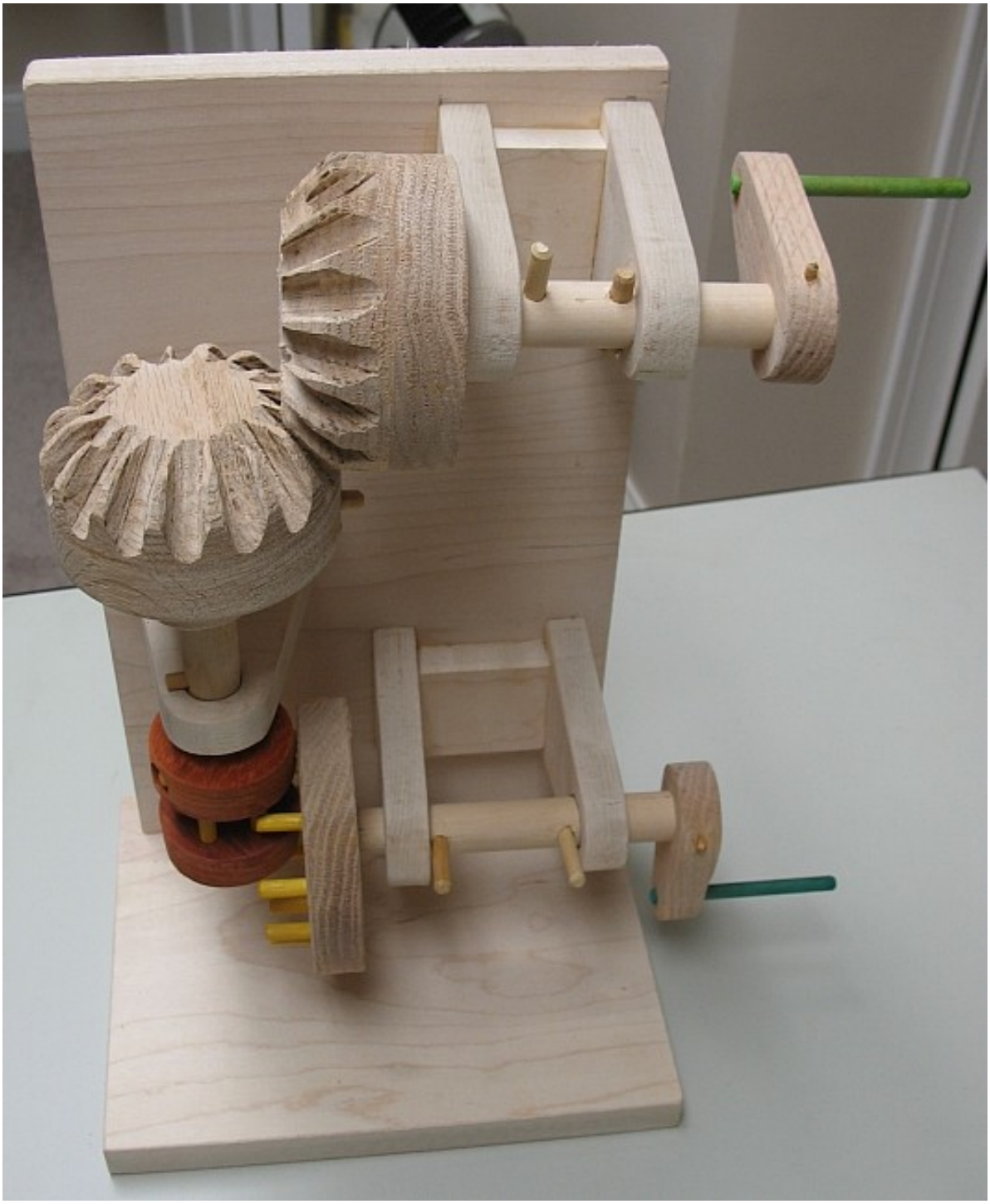


Grist Mill Gear Set

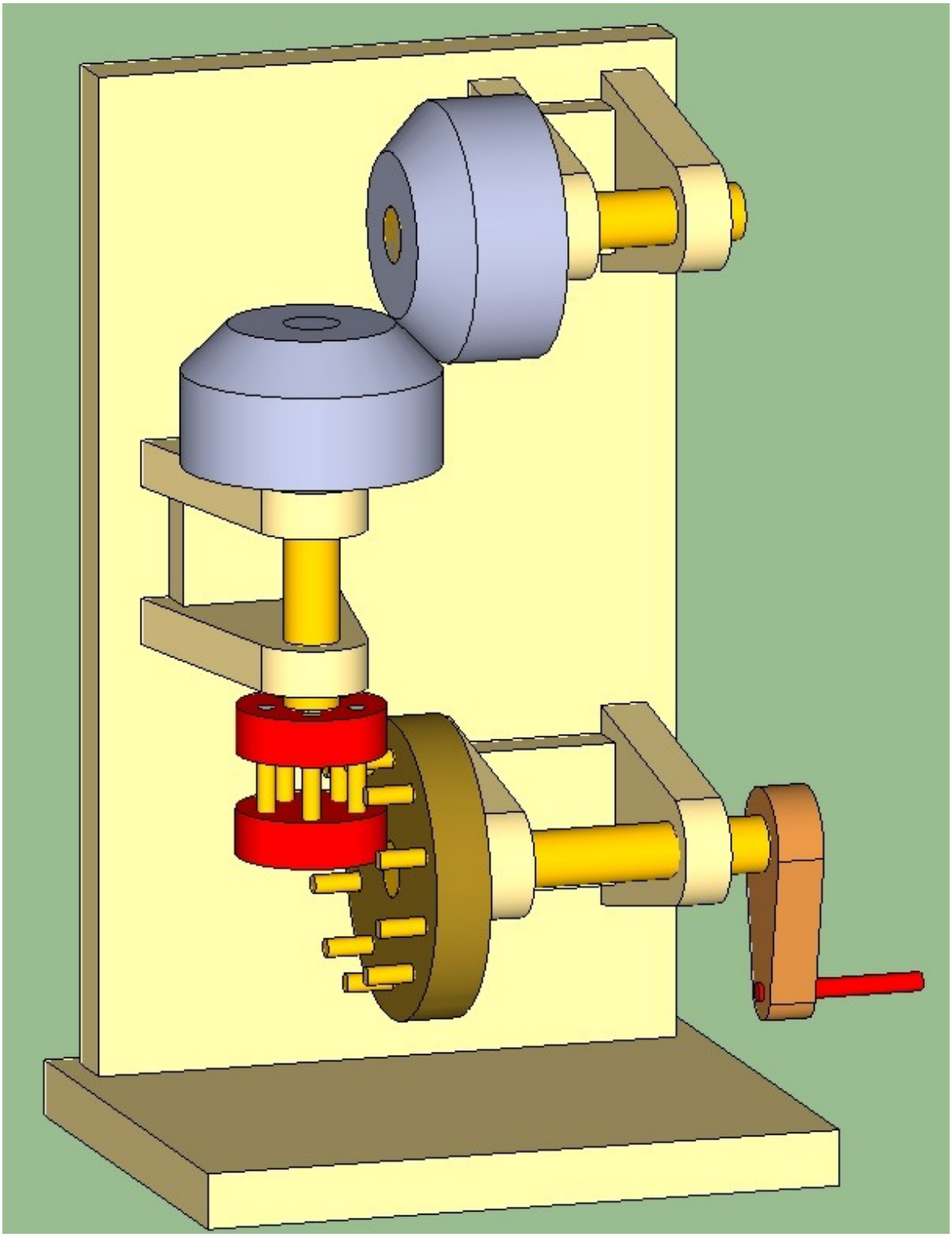
I designed them in Sketchup. I also made an animation to see how well the grist mill gears worked: https://www.youtube.com/watch?v=30ns1ARMPHU

When I did the animation, I only focused on the big wheel driving the small wheel. I did not model the small wheel driving the big wheel. I found the design to be very sensitive to the length of the pins on the small wheel. When I designed the entire model, I gambled on being able to drive the gear train backwards and put a crank to drive the spur gears on top.

After I got the model built, I found the lower crank drives the gear train in either direction fine. But when I tried to use the upper crank, it locked up the grist mill small gear immediately. I will have to remove the upper crank from the model. The grist mill gear will not work in the direction of the little gear driving the big gear!



Here is Google Sketchup of the model without the upper crank:



I used a new technique on this project to hold the gears to the shafts. I drilled a 1/2" pilot hole probably 1/2" deep, then drilled 1/4" hole as deep as the Forstner bit would go. I then fit a removable 1/4" dowel into the hole. You can use needle-nose pliers to remove the dowel for dis-assembly of the model. I also used both yellow and green dye to spruce up the amount of color in the model.

And here is the finished model:

Youtube Video

And here is a link to a YouTube video of the finished model in operation.

Comments on this project:

Designing and figuring out how to make the bevel gears was quite a challenge. The grist mill gears are fun to watch operate.

On this project, I used two colors of dye to spruce up the project. Yellow for the grist mill drive gear pins, yellow for lantern gear of the grist mill set, and green for the dowel retaining pins. It turned out pretty colorful.

This model is on the big side, but I like the size of both the bevel gear set and the grist mill set.

In Retrospect, 14 years later, in 2024

It has always bugged me why the grist mill or peg gears would only operate in one direction, versus operating backwards! I sort of "winged it" when I quickly designed the set. I probably need to investigate and see if there is a more scientific way to design this gear set.

I take great pride in the quality of the workmanship of my finished woodworking projects. The bevel gears are not of great quality.

Looking back, I probably should have designed them with a smaller number of teeth, so I had more material between the teeth, and therefore less likely to break. I also could have run the wood grain the other way, so there was chance of chipping or break-out.

But I was working full-time as an Engineer back in 2010, and I was restricted to doing my woodworking projects on week-ends. So I did pretty good designing and building both gear sets given those factors.